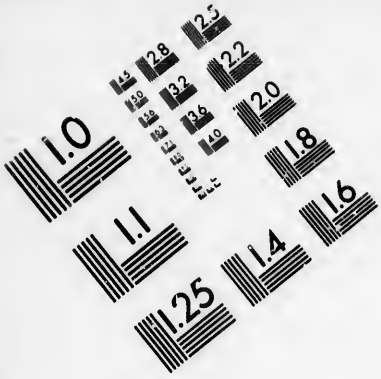

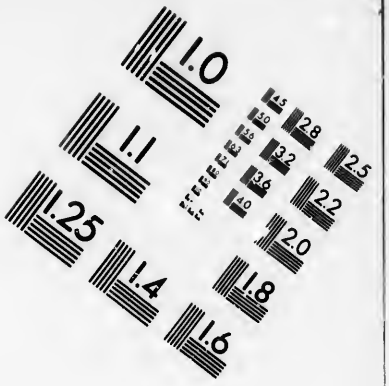

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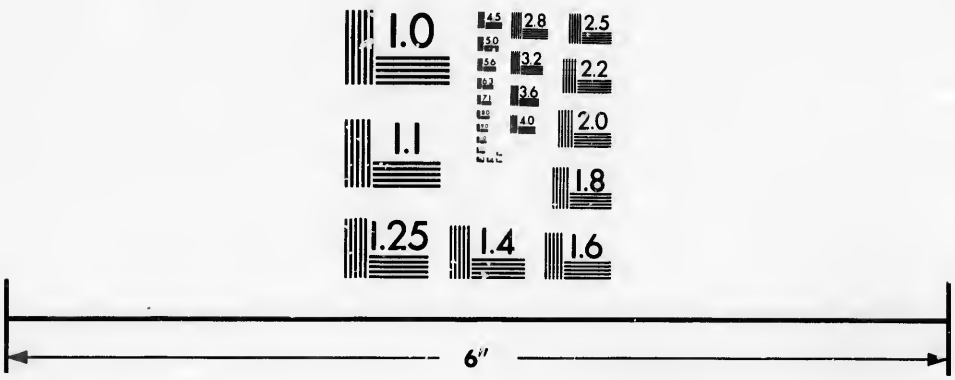

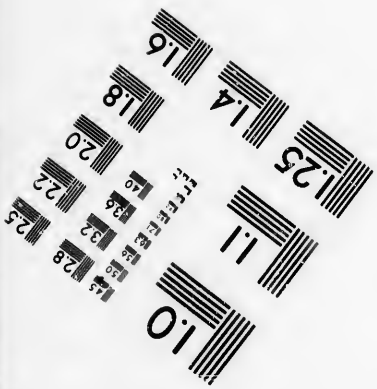

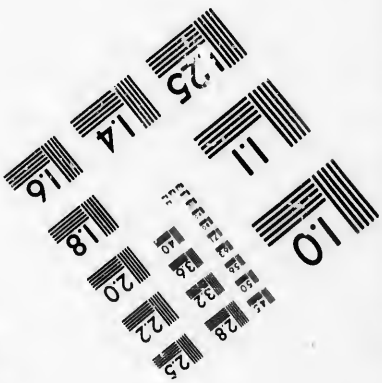

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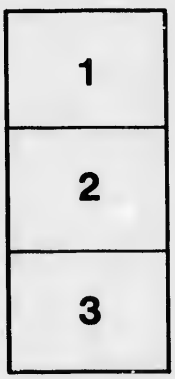

Canadian Society of Civil Engineers.

INCORPORATED 1887.

TRANSACTIONS.

N.B.—This Society, as a body, does not hold itself responsible for the facts and opinions stated in any of its publications.

To be read on Thursday 9th, April.

SEWERAGE AND WATER-WORKS OF ST. JOHN'S, NEWFOUNDLAND.

By Alan Macdougall, M. Can. Soc. C.E., M. Inst. C.E.

Devastated by a fire which left hardly a single building standing in 1846, hampered by the peculiar policy of the Imperial Government towards the colony, which only received Responsible Government in 1854, governed by the Provincial Government as a part of the general property in the island, and only now permitted to enjoy a partial self government, and sadly hindered by a most curious system of land tenure, the city of St. John's certainly did not rise like the Phœnix out of its ashes! The city has had a great deal to contend with during the past 45 years, and more so in the period more immediately passing away. Absent landlordism and absent capitalists draw all the profits from the city, and leave the money makers to battle with all the expenses attendant upon the building up of the city. The whole of the city is built on leasehold. Nearly all of the earlier leases are non-renewable, and contain provisions that all improvements belong to the owners of the land at the termination of the leases. The system of land tenure savours more of the feudal and vassal system than of nineteenth century advancement.

The city of St. John's is built on a steep hill-side. It is surrounded by high steep hills rising 300 to 600 feet above sea level, with a land-locked harbour of 345 acres in extent.

The entrance to the harbour is through a narrow gorge bearing evidence of having been scoured out by glacial actions. The rocks in the neighbourhood are Huronian.

The present population is estimated at 30,000. Nearly all the buildings are of wood; the only stone and brick buildings are on the two principal business streets—Water and Duckworth. Public buildings, such as Government house and buildings, the principal churches and so forth, are of stone imported from Ireland. After the fire no re-survey was made, or any regulations passed governing the erection of buildings; consequently a town has grown up full of curious irregular streets, full of encroachments and narrow spaces such as one meets with in European Continental cities, where people can almost shake hands out of their windows. The streets are all closely built upon, there are no spaces between the houses; the blocks are solid masses, in many cases without any means of access to the rear of the houses, and in many cases the backs almost touch each other.

The streets rising from the harbour are very steep, the ruling gradient is about 1 in 9. The rear parts of houses in many streets are so much below the street level, the lowest portions cannot be connected to the sewers. The city is practically built upon rock, it crops out everywhere in the streets; huge masses overhang the backs of houses; it has been quarried out to allow the houses to be built. The problems relating to sewerage are complex and interesting from a variety of circumstances, the discussion of which will occupy more space than the limits of this paper will allow.

The population consists largely of working people, who are poor. Nearly everyone of them is engaged in the fishing trade, either seal or bank fishing. The houses are of poor construction, of small rental, and incapable of bearing the expense of such sewerage and plumbing as the experience of the present day teaches to be necessary. Under one roof can be ordinarily found six to eight different families, occupying one or two rooms each, and in many cases being the proprietors of these small apartments, thus illustrating the "tenement" house of the Eastern

States, or the "flat" of Scottish cities. These people are not able to put in "the latest modern improvements," nor have they the space to devote to them. The buildings and occupants are far from squalid; the occupants are cleanly and tidy people, with a very marked taste for flowers; the houses, generally, in good order.

Under the present régime, which was inaugurated two years ago, when the city received its present form of government, great and marvellous changes have been effected. The present municipal control is vested in a "municipal council;" it is expected that at the next meeting of the Legislature, a proper form of civic government will be granted to the city. When this is effected its influence on the good of the city will be rapidly felt.

That portion of the town site which slopes towards the harbour was in the early days intersected by a number of natural waters, twelve or fourteen in all, which were used for a long time for culinary and dietetic purposes. With the gradual growth of the population, these water courses were turned into drains or storm-water courses, and in the ordinary course of events they became sewers, discharging into the harbour.

WATER SUPPLY.

The first effort to obtain water supply was made about 1850, when water was brought from a small lake situated at the hill commanding the entrance to the harbour, called "Signal Hill." The lake is 300 feet above the sea level. A small distribution was made along Water street, on which the pipes still remain, supplying water from the present system under a pressure of 100 lbs.

In 1858, the present system was laid out by Messrs. Robson, Forehman and McCall of Glasgow. The water is brought from Windsor Lake, 4½ miles northwest of the city. The surface of the lake is 500 feet above the tide water; it has a surface area of 1370 acres. The grade for the first mile is very flat, compared to the rest, particularly to the last 2½ miles, where the fall is 273 feet. The supply of water was not satisfactory, and the Company who originally constructed the work consulted Messrs. Kinipple and Morris in 1873. Then Mr. Morris came to Newfoundland and made exhaustive researches, which were presented in a full and carefully detailed report. The pipe as originally laid was 16 ins. diameter for its entire length. Mr. Morris found, as would be expected, that the portion nearest the lake was incapable of supplying to its full capacity the pipe nearest the town. He also found a remarkable and unnecessary waste of water going on: in some houses in the lowest lying parts, where pressure was greatest, there were no fixtures on the pipes, only a bent end, with the water flowing at the full bore.

After making many practical suggestions as to prevention of water waste, he advised certain alterations on the sizes of the pipes, which were carried out. A 24 inch supplanted the 16 in. for 903 yards from the lake, two double 16 inch stretched for 1496 yards further, and the single 16 inch remained for the balance of the distance.

This arrangement worked well for some time, though it did not give entire satisfaction. In 1883 Mr. John Martin, M. Am. W. W. Assoc., added a 12 inch pipe to the end of the double 16, for a distance of 1188 yards, bringing it to the head of the heavy grade next the city. This addition now balances the relative discharging capacities of the grades, and keeps the single 16 inch full. The daily flow is now close on 5,000,000 gallons (Imperial) per day.

In spite of these gradual approaches to the full capacity of the pipe, the supply was unsatisfactory, as the upper part of the city had very poor supply and low pressure, and during winter was without water.

The writer has just finished an examination into the causes of the dearth of water in the higher levels. He finds that an undue amount of water is run to waste in winter through constant flowing taps in the lowest levels; that economy in the use of water is not practised in winter; and that the main supplying "Water street" robs the other streets, the water having to rise to the upper levels chiefly from this low level of Water street. Observations taken with a pressure gauge have agreed closely with calculated pressures. The alterations recommended by the writer will probably be carried out next year, when all the trouble, it is hoped, will pass away.

The pipes are of cast iron, with turned and bored joints; they have

been imported from Scotland till lately, when they were cast in the city. Those made in city were cast on their sides. A short distance of the supply main was laid with leaded joints. The superintendent informed the writer he found the change of temperature in the water affected the leaded joints, and that they began to leak after two years, and had to be attended to every second year. The turned and bored joints had never given him any trouble. This seems to be an unusual experience.

House services are of lead, stop cock boxes are of cast iron, placed over the valve, close to the main, and not in the service on the sidewalk.

Fire hydrants are of the Leadbetter pattern, which was the first one used here; it has been adopted ever since.

Public fountains are scattered over the city; they are constant flowing, discharging from two to four and in a few cases more gallons per minute. Self-acting and closing valves are now being attached to the fountains.

There are about:

9½ miles of mains.

2000 house services.

165 fire hydrants.

70 public fountains.

The quality of the water is good, soft, pure, potable water, well adapted to culinary and dietetic purposes. It is rather hard on steam boilers, pitting the shells and tubes severely. The latter have to be renewed frequently, inferiors ranging from six to twelve months.

The supply main from the lake was cleaned out in 1885, by Mr. H. C. Burchell, M. Can. Soc. C. E., during Mr. Martin's absence on sick leave. The writer is very pleased to state that Mr. Burchell will shortly give to the Society a paper on this very interesting piece of work. The pipes have been cleaned out every two years since that date (1885), about a quarter of an inch of rust or incrustation forms in that time. A description of the present method of cleaning the pipes will be given by the writer as an addendum to Mr. Burchell's paper.

The position of many of the lakes is remarkable, they are on the highest points of the water shed. Windsor Lake has a water shed to its south of perhaps eight square miles, otherwise it is at the highest point of land. The level was raised 9 feet when the works were constructed; the top of the intake pipe is 6 ft. 6 ins. below high water, and 2 feet 9 ins. below low water. The water is drawn from the shallowest end. Had the pipe line been carried up the valley immediately to the north of its present line, a much more uniform hydraulic grade could have been established, and water drawn where the lake is 40 feet deep. The lands immediately surrounding the lake are nearly all controlled by the City, who now own the water-works.

A small dam of rip rap encloses an area of about half an acre, in which the intake pipe is placed. A good deal of trouble was experienced from anchor ice; this has been cleverly overcome, by forming a number of telegraph poles into an open raft. They are fastened together by wire, about 10 feet apart, and anchored over the mouth of the pipe. The ice forms quickly between them, and prevents the formation of anchor ice.

The annual rainfall for the past six years is about 49.15 ins. per annum. A careful record of water level since the commencement has been kept by the superintendent, who kindly permits its publication in this paper. The gradual fall in the lake level is due to the equalization of the discharging capacities of the supply main.

There are good reasons for believing the lake is supplied by springs: it is the last sheet of water in the neighbourhood to freeze, and the last to thaw out in spring.

The works were constructed by a joint stock company with a capital of $400,000, the interest of which was guaranteed by the Government, who afterwards purchased the works, and handed them over to the City, bonding the cost of them at $423,860.

The estimated revenue is $30,000 per annum.

SEWERAGE.

The natural water course which intersected the city became in course of time more or less polluted by sewage. Large stone drains or culverts, rectangular in section, were built from time to time on the lines

of the water courses, consequently they are crooked, and in too many instances situated on private property. In later years the Government, through its Board of Works, constructed a number of sewers, varying from 12 to 24 ins. in diameter, without regard to any systematic plan. The pollution of the water front of the harbour and necessities of life demanded a better arrangement. Messrs. Kinipple and Morris, MM. Inst. C. E. of London, were again consulted, and prepared plans for a system of sewerage on the combined system. They proposed to collect the sewerage at a point in the eastern end of the harbour, and either discharge it there at the level of half tide, or raise it by pumping to a higher level and discharge it into the open sea. They strongly recommended the latter course, in which they were undoubtedly correct. Two outlets were proposed: one directly into the open ocean, by which plan the works would have cost £80,116 stg. ($390,165); the other at the entrance to the harbour at a rock locally known as the "chain" rock. By this system the works would have cost £74,886 stg. ($364,595). Their scheme proposed 19 miles of sewers. No action appears to have been taken on this report.

Some years after, in 1886, Mr. H. C. Burchell, M. Can. Soc. C. E., the Government engineer, was instructed to report on the sanitary condition of the city, which was followed up by another report from him in February, 1887, "on the subject of improved sewerage for the town of St. John's." Mr. Burchell went over the ground very carefully, and prepared an exhaustive and valuable report, in which he differed materially from Messrs. Kinipple and Morris, and recommended the separate system, leaving the existing sewers for storm water and surface water sewers. He selected his point of outfall at the chain rock. Under his proposal there were about 14½ miles of sewers, which he estimated to cost $205,875.

In March of 1889, the City consulted Mr. Rudolf Hering, M. Can. Soc. C. E., who prepared the scheme which is now being carried out. He recommended the Rawlinson's system of small sewers, the principles of which are well known to the members of the Society. He adopted the chain rock as the permanent outfall. Under his directions, the City Engineer, the late Mr. C. F. Harvey, has worked out the details of the system. There are 15½ miles of sewers contemplated, at a cost of $272,183. Mr. Harvey added $75,000 for improvement of old sewers, culverts, superintendence, storage, etc., otherwise his estimate would not differ materially from Mr. Burchell's.

Copies of these three reports can be found in the library.

The intercepting sewer was calculated to receive as much roof water as the maximum quantity of sewage, which was assumed at 12.5 cubic feet per section, for 60,000 persons, on a basis of 75 gallons per head per day.

The grades are steep everywhere, except for the intercepting sewer on Water street, which is 1 in 1000. A portion of this sewer (and the most difficult portion), the outfall and the portion next to it, are now being constructed. About 2,000 feet are in tunnel work. The Huronian rocks are generally very hard, and form a good roof for the tunnel, which will dispense with the need of arching the culvert, except in a few places where the rock is much shattered, and pockets of loose earth are encountered.

A good many lateral sewers have been laid, which are temporarily connected to the existing surface water sewers. As the construction of the Water street intercepting sewer is completed, the several lines of branch sewers will be connected to it, leaving only storm water to escape into the harbour. The western portion of the city lies rather low, the intercepting sewer for it is also on Water street, with a temporary outfall into the harbour; it is intended eventually to raise this by pumps for a short lift, and discharge the sewage at the permanent outfall.

A temporary outfall has been selected at the eastern end of the harbour. The permanent outfall will be at the mouth of the harbour, at the "chain rock"; at this point the discharge will take place into a strong current and ensure perfect security. The outfall sewer will be in rock tunnelling for its entire length, and discharge 6 inches above low water mark: the cost is estimated at $35,000.

The ordinary range of tides is 3 feet 6 inches, extremes tides rise to 5 feet 3 inches.

TUNNEL.

The tunnel under Water street is 2000 feet long; it is six feet high by 4 feet wide, and 6 inches below the sole plate of invert block, to allow for a French drain. Being the first work of its kind, a good deal of experimental work had to be carried out regarding prices and mode of construction. The work was all hand drifted. Dynamite was used. A great deal of difficulty was experienced from want of proper ventilation. The work was let in short contracts to working miners, who each worked from a shaft. There are six shafts, the greatest distance between any two being 400 feet and the average 320 feet. Ventilation was eventually effected by placing a stove at the head of the shaft, and leading air pipes from the workings to it. The men suffered a good deal from foul air and damp.

In addition to the hard and irregular formation of the rock, much trouble was met with from shattered roof rock, wet seams and loose earth.

Two surface water sewers caved in and one water pipe burst. After battling for a considerable time with the water and pumping it, the eastern portion was abandoned and filled rapidly. This work was attended with great difficulties during construction, and is a satisfactory record to the energy, perseverance and engineering skill of the late Mr. C. Harvey.

TRENCHING.

In digging the trenches, benching is not used. The earth is thrown up at once from the bottom of the bench, where it does not exceed 9 or 10 feet, by long handled shovels—the blade is smaller and sharper in shape than the ordinary navvy shovel.

MATERIALS.

The City supplies all the materials required, as recommended by Mr. Harvey in his report; the contractors are called on to cut and fill in trenches, build brick work, etc. The City employs its own pipe layers.

The bricks were purchased in Boston, as there were no home made obtainable. This year two firms have manufactured on an experimental scale; there is good clay within reasonable shipping distance. Some of the home-made bricks were first-rate, well shaped, hard-burned clinker brick, quite as good as the American article.

The sewer pipe is chiefly Doulton's make, and ranges from 9 to 24 inches. There are two qualities, the "London" and "Liverpool" Doulton. The first is a hard stoneware substance, with light yellow glaze; so far it has proved very satisfactory; it cuts more easily and regularly than the other qualities. The other qualities are similar to the best grade of Ohio pipe. Scotch pipe has been used to some extent, they have not much of it in stock. All necessary fittings, such as channels, bends for manholes, half pipes, gulleys, junction blocks, are Doulton's make. The invert blocks of the same make have a large radius; the chord is 10 to 10½ inches, ver. sin. 2 to 2½ inches, which makes a large invert. The breakage on the pipes during shipment is very great, often 50 per cent.; this adds greatly to the cost of the pipe.

The cement is of two brands, English and Alsen. The latter, a German brand and a slow setting cement, gives good satisfaction and makes excellent work.

Under the Board of Works a good many sewers were laid, Scotch pipe being largely used. In one 12 inch sewer which had been laid for about 15 years, on a very steep grade, 1 in 8, it was found that no wear had taken place, the pipe was sound and hard, and almost as good as when laid. The large sized pipes, 18, 21 and 24 inches, break in the same manner as those described in Mr. Rush's paper,* on the axis of the pipe at the crown and at the haunches.

*Toronto Sewers, Vol. II, Part II.

MANHOLES.

The manholes are circular, 4 feet diameter at the bottom, tapering to 2 feet at the top, with junctions of sewers arranged according to Rawlinson's suggestions. They are built in 8 inch brick work.

There are a few lan-pholes and inspection tubes.

Dirt baskets are suspended under each cover, which catch a large quantity of dirt.

SEWER INSPECTION.

Mr. Ryan, the sewer inspector, has succeeded in constructing an effective light, or lamp, for inspecting and located junctions. He has located a junction at 68 feet from a manhole, in a 9 inch sewer. A float or boat at the radius of the sewer, and nearly half its diameter, carries a looking glass reflector with a hood over it. The reflector is placed at 45° to the axis of the sewer, at a convenient distance from it the light is placed. By fastening it on a pivot, he is able to read right and left hand as desired.

The boat is pushed up the sewer by means of jointed rods.

Manholes are examined weekly, dirt baskets cleaned, and in many cases sewers flushed from the hydrants. Automatic flushing cannot be introduced, as there is scarcity of water in many streets newly sewered.

During construction a careful record is kept of the depths of rock and earth; the position of every manhole and junction for private drain connections is noted. After each sewer is completed a plan is prepared shewing the positions of the manholes and junctions, and on the same sheet a profile is plotted, giving the depths of cutting and depths of rock and earth passed through.

Whenever it is necessary to take up a pipe, either from its being defective or to put in a junction in its place, instead of stripping several pipes and trying to spring them, Mr. Ryan adopts the plan of cutting off one half of the flange. By cutting off the upper part of one flange or socket in the sewer, he can raise the pipe easily, and by cutting the lower portion of the socket of the pipe to be put in, he is able to replace a pipe without disturbing more than one pipe. The pipe is turned round and the broken part placed upwards; the defective sockets are made good with cement. He uses fire clay instead of cement in such places, and under water has found it to set and become effective when cement washed out. This is a novelty the writer has not met with in his practice, the experience in St. John's has proved most satisfactory.

COST OF WORK.

The engineer's department has not had the advantage of experience gained by many years of work; it had also to deal with a hard and troublesome rock to blast. Prices of work done compare favourably with Ontario. Laborers get $1.00 per day; bricks cost $13.00 per M. and $6.00 per M. to lay them; bricklayers' and masons' wages are $2.30 per day; cement costs $2.70 to $3.00 per bbl. as imported by the Council. Pipe is much the same as Ohio pipe prices. Contract work: earth trenching 50 to 60 cts. per cubic yard; rock, from $2.50 to $2.60 per cubic yard. Day time, earth trenching 30 to 35 and rock $1.90 to $2.00 per cubic yard. Tunnelling costs from $7.50 to $12.00 per cubic yard, including timber framing.

ROADWAYS.

The roadways are all macadamized, the surface is in good order, well kept up, and in their general condition the streets compare favourably with Canadian streets. Like all macadamized surfaces, they are muddy; still the writer knows many western cities which are notorious for muddy streets.

Water channels are pitched with cobble stone. Kerbs are of a local slaty rock, 2½ to 3 ins. thick, and not very well dressed. The pitching of the water channels is well done, the stones are uniform, oval and well shapen.

Gulleys are of the old Board of Works fashion. As they are replaced, either the Doulton gulley or proper brick ones are used. It is necessary to have a good depth under the trap, to catch the mud and débris. They are constantly cleaned out.

The city owns a ten ton Aveling & Porter steam road roller.

SCAVENGING AND STREET CLEANING.

No systematic arrangements exist for sweeping and scraping the surface of the streets, as in the present financial condition the revenue will

not permit this to be carried out on a large scale. The scavenging is more directly carried out in the narrow steep streets and lanes which form the "poor" part of the city. The night soil is collected under the "pail system;" the pails are put out after 10 o'clock at night (22 o'clock). At midnight, the carts leave the stables to collect night soil, which they do in about 3½ hours; the horses are fed, start out at 4.30 to collect ashes, which takes the same time; then about 9 o'clock the carts again go out to collect garbage and sweep the streets, and finish about 12 o'clock. There are only 14 carts for night soil and 14 for garbage and 14 horses, which are hard worked under existing arrangements. The carts for night soil are of iron, semicircular, hung on trunnions, and self-tipping. The lid is held down by clamps, and in it is a manhole for emptying the pail. The carts are washed out at the stables every day.

The system of scavenging is well and ably managed and handled by Mr. Hughes, the inspector. The writer devoutly hopes that no steps may ever be taken to impair the efficiency and usefulness of this department. It is worked with the least offence to the citizens, and the very best results.

The night soil is carted to the adjoining farm lands, where it is covered during the day with garbage and street sweepings, the farmers frequently adding earth and peat bog to the mixture. There is a good demand for this material, it is readily disposed of; during summer it is put on lands some distance from the main roads, and so far the work has been carried on without creating a nuisance.

The work costs about $17,000 per annum, the City owns the whole outfit.

FLUSHING OF SEWERS.

It is a part of the sewerage plan to have flushing tanks introduced at proper points on all the sewers. This is not yet practicable, owing to the want of pressure and scarcity of water in the higher parts of the city, where much sewerage has been put in. All sewers are examined weekly, and flushed from the fire hydrants, and soon a system will be at work flushing them by automatic discharges filled from the waste water of the public fountains, as well as by direct supply in the way recommended by Sir Robert Rawlinson and Mr. Hering.

SANITARY WORK.

The writer desires to record his appreciation of the excellent sanitary arrangements which exist. The nature of the subsoil has fortunately prevented the formation and use of privy pits, and compelled some form of removal of night soil. The record of the past is not flattering to the manners of the citizens, but since the present régime has been inaugurated a great change for the better has taken place. The sanitary department have had to deal with a poor class who have not the means to introduce water and sewerage into their houses. The apartments which serve as a domicile are from one to three rooms, there is not therefore accommodation for a closet. The custom of the country differs from Canada in the matter of house heating, the principles and practice are much more British than Canadian; as a general rule, houses are not heated. In the very coldest weather, a small hall stove or "heater" tempers the atmosphere of the house, but as far as the writer can learn can hardly be said to heat it. If this condition exists in the houses of the upper classes, it is useless to expect those of the lower to be warmed; therefore if water, even, were introduced into their houses, it would certainly freeze.

The writer has had sufficient experience of sanitary work in Western cities to know what the condition of drainage in cheap houses leads to, and the troubles caused by it, and the dangers to which inmates are subjected. In St. John's he finds a system of water supply from public fountains in full working order, the people accustomed to draw from them, and suffering no inconvenience from the arrangement; the slops emptied into well-formed and graded side channels, which are carefully swept every day, and in numerous streets flushed by the waste water of the fountains; a daily collection of garbage, and a nightly one of night soil. Here everything tends to internal cleanliness of the household, and no danger of dissemination of disease from sewage gas can exist

from defective plumbing arrangements. On the other hand there is a certainty that if sewers were led into these houses, and any plumbing fixtures, especially water closets, introduced, there would be bad joints, stoppages, breakages in pipes, and resultant outbreaks of zymotic diseases. He therefore advised the Municipal Council to give frequent connections to the sewers by means of gullies, placed so as not to intercept surface water, for carrying away household water, to flush the sewers, and to continue the use and daily collection of night soil though the "pail" system.

The Board of Health, a body similar to the Provincial Board of Ontario or Quebec, is endowed with extraordinary power, which it does not hesitate to use. With such a mentor over it, the Municipal Council has small chance to relax its rules and regulations regarding the proper preservation of the public health.

The city has plumbing by-laws, based on the practice of large American and Canadian cities, which are perhaps too exacting for its present requirements. It will not be practicable to put fixtures into small houses renting under $40 per annum, when the plumbing by-law calls for self-flushing cisterns and water-saving appliances, and expensive cast iron soil pipes extending through the roof of the house. One certain result of these cold houses will be frozen pipes, traps, and other fixtures. To put in deep hoppers with the trap below the frost line, and flush them with the ordinary rim flush, will not answer, as the writer knows by experience. He favours and has suggested making a trial of a trough closet in a proper building under Municipal control, in which a self-acting flushing tank would discharge at short intervals—these closets to be common to a range of two or three houses, having compartments for males and females, and close by them he would place yard slop hoppers for the use of every two houses. By careful attention to these under the special exigencies of the city, he believes a successful solution of the problem will be arrived at.

APPENDIX No. 1.

AVERAGE RAINFALL FOR EIGHT YEARS.

	1873	1875	1876	1879	1880	1884	1887	1888
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
January	4.51	....	3.46	4.74	3.58	5.03	4.35	7.72
February	4.60	....	2.34	2.42	6.14	5.23	1.90	5.01
March	2.86	....	4.29	3.84	4.40	5.84	6.77	3.78
April	2.57	....	1.67	6.87	3.20	4.77	4.96	3.41
May	3.06	4.67	4.13	4.33	1.98	7.71	4.05	3.70
June	2.05	2.56	1.19	3.44	6.65	1.40	1.01	3.90
July	3.79	3.05	4.09	3.96	2.88	6.87	2.10	2.13
August	2.16	3.08	7.47	3.21	1.97	2.64	3.75	4.43
September	2.51	3.56	8.75	2.70	2.84	2.19	5.78	1.63
October	2.92	6.14	4.19	4.17	....	5.03	4.42	10.00
November	8.14	3.48	3.68	4.22	3.23	5.44	5.19	4.19
December	8.75	1.70	2.99	2.17	5.20	4.65	4.81	2.73
	47.92	28.24	48.25	46.07	42 07	56.80	49.09	52.63

GREATEST DAILY RAINFALL.

	1872		1875		1884		1885		1887		1888	
	Ins.	Hrs.	Ins.	Hrs.	Ins.	Hrs.	Ins.	Hrs.	Ins.	Hrs.	Ins.	Hrs.
January	....	....	....	....	1.17	13	0.82	7	6.66	9	....	....
February	....	....	....	....	0.61	4	....	....	2.40	24	....	....
March	....	....	....	....	0.86	10	1.37	9	1.04	6	....	....
April	1.48	12	....	....	....	....	....	....	....	....	....	....
May	3.47	22	1.63	7	1.64	17	1.76	12	....	....	....	....
June	1.63	13	1.80	10	0.63	6	1.93	22	....	....	....	....
July	1.77	10	1.30	2	2.26 0.88	21 5	1.49	24	0.76	3	0.57	1.30
August	1.22	....	....	....	0.88	4	0.91	....	....	....	....	....
September	2.16	14	....	....	....	....	....	....	....	....	....	....
October	3.71	8	....	....	1.14	12	1.48	12	....	....	1.20	3
November	1.27	....	....	....	1.56 3.52	9 26	1.27	15	....	....	2.78	12
December	2.07	15	....	....	....	....	....	....	....	....	....	....

APPENDIX No. 2.

WINDSOR LAKE. DEPTH OF WATER OVER INLET PIPE.

Date.	Month.	Thickness of ice	Low water levels.			
			Date.	Depth on inlet pipe	Depth on waste weir	
1862	Febr'y. 2	29 ins.	Sept. 1	6 ft. 6 ins.	4 ins.	Water turned on to town 16 June, 1862
1863	1	30		6 6	4	
1864	3	33		6 6	5	
1865	2	28		6 6	6	
1866	4	34		6 6	4	
1867	1	29		6 6	5	
1868	2	32		6 6	6	
1869	3	29		6 6	6	
1870	1	33		6 6	5	
1871	4	29		6 6	6	
1872	1	30		6 6	5	
1873	2	32		6 6	5	
1874	1	35		6 6	6	
1875	3	30		5 1		Water supplied thro' 24 inch pipe, Mr. Morris' plan.
1876	1	29		5 6		
1877	2	32		5 0		
1878	1	33		5 2		
1879	4	33		5 0		
1880	1	32		5 4		
1881	3	31		5 0		
1882	1	34		5 3		
1883	2	29		5 6		12 in. pipe added, Mr. Martin's plan
1884	1	30		4 0		
1885	4	29		3 4		
1886	1	30		4 2		
1887	2	32		4 0		
1888	1	34		4 3		
1889	5	29		3 10		
1890	3	34		3 9		

APPENDIX No. 3.

CEMENT TESTS BY THE LATE MR. C. J. HARVEY.

Name of brand.	Neat cement.		Cement, 1 part. Sand, 3 parts.	
	Age in days.	Tensile strength.	Age in days.	Tensile strength.
		lbs.		lbs.
Alsen's Portland.				
Average of 4 samples.	7	416.5		
10 "			7	138
10 "	28	460.3		
13 "			28	188.9
English Portland. (brand not known)				
Average of 4 samples.	7	364.75		
9 "	28	41 .9		
6 "			28	123.66
Tests by Mr. McAlsen, in stock abt. 12 months.	Dougall,	October, 1890.		
Average of 5 briquettes	8	300		
Whites, in stock 12 months.				
Average of 4 briquettes	8	188		
Whites, this year stock				
Average of 4 briquettes	8	198		

APPENDIX No. 4.

COST OF SEWERS.

Name of Street.	Diameter inches.	Depth feet.	Length feet.	Cost.		Cost per foot	Nature of soil.
Feavers Lane.. ...	9	5	186	76	90	$0.41.1	Hard gravel and rock.
Chapel Street.....	6	5 to 7	200	133	63	0.66.8	" "
Darling Street.....	9	8 to 10	638	736	68	1.15.4	" "
Bacon's Lane.....	6	4 to 7	108	51	12	0.47.3	" "
Knight & Carew Sts.	9	5 to 9	902	704	22	0.78	Gravel
Water Street West..	15 & 18	6 to 11	260	416	77	1.60	Hard gravel and rock.
Lazybank Road....	9	5 to 10	1425	1596	40	1.12	
Gower Street East..	9	7 to 9	134	228	63	1.70	
Dogstown.....	12	5 to 7	491	550	86	1.12	
Balsam Street.....	9 & 6	7 to 9	426	464	39	1.10.5	Hard gravel.
Brine Street.....	9	5 to 10	788	633	69	0.80.4	" " and rock.
Plymouth Road....	9	6 to 9	303	244	60	0.80.4	" " and boulder.
White Cat Hill....	9	5 to 6	135	82	90	0.61.4	Hard gravel.
Sanitary Stables...	6	6	117	46	65	0.39.8	Gravel.
Claney's Lane.....	9	6	20	11	20	0.56	Gravel and rock.
Haward Ave.....	9	8 to 9	882	1319	27	1.49.6	Hard gravel and rock.
James Street.....	9	8 to 9	719	500	55	1.25	" "
Monkstown Road..	12	5 to 9	1290½	1440	97	1.11.7	" "
Fleming Street	9	7 to 9	421	467	36	1.11	" "
Maxse Street.....	9	7 to 9	486	411	75	1.05.5	" "
William Street.....	9	7½ to 10	793	942	78	1.18.8	" "
Monkstown on Hall.	12	4 to 11	1176	936	20	84.2	Gravel.